Introduction to Annex 43:

*Fuel driven sorption heat pumps*
*For residential and small scale commercial heating applications*

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University of Warwick

IEA National Teams Meeting for the UK Heat Pump Industry, DECC, 18\textsuperscript{th} August 2014
Contents:

• Background to Annex 43 - Fuel (Gas) Driven Sorption Heat Pumps

• State of the art and new developments
Reasons for gas driven heat pumps

• Buildings with radiators which might need higher temperatures
• Replacement of existing boilers, minimal change of existing system
• Grid balancing – inability of electricity grid to cope with an all-electric future
Reasons for a new annex “Fuel driven heat pumps”

• Market for fuel driven heat pumps is rising (7000 in EU so far)
• Emerging technology just starting to enter market
• Big need for quality assurance measures
• Big need to optimize best system configurations for different applications
• Need for standards on test procedures
• Need for common understanding of field tests.
Focus:

- Fuel driven heat pumps for residential and light commercial (e.g. < 50 kW)
- Focus on heating mode, reversible allowed

Goals:

- Easy and sustainable market entrance and deployment
- Identify market barriers and opportunities
- Identify the potential markets and importance in future energy systems
- Identify market supporting measures
Participants:

<table>
<thead>
<tr>
<th>Country</th>
<th>Organization(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>AIT, University of Graz</td>
</tr>
<tr>
<td>France</td>
<td>GDF, GrDF, boostHEAT</td>
</tr>
<tr>
<td>Germany</td>
<td>Viessmann, Vaillant, Sortech, Fraunhofer ISE, Univ. of Berlin (ZAE), Stiebel Eltron</td>
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<td>Italy</td>
<td>Robur, CNR-ITAE, Politecnico di Milano</td>
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<tr>
<td>USA</td>
<td>ORNL</td>
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<tr>
<td>UK</td>
<td>University of Warwick, Delta-EE</td>
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</table>
Work structure

A: Generic systems and system classification (ISE)

- WP1: Collection of technology and market relevant data
- WP2: Development
- WP3: System classification
- WP4: Development of generic systems and system boundaries
Work structure

B: Technology transfer (Warwick)

- WP 1: link research and industry (workshops) (Warwick)
- WP 2: New materials (database) (ISE)
- WP 3: New components/systems (CNR-ITAE)

Under WP1 i-STUTE, EHPA and Annex 43 hope to organise a gas fired heat pump workshop for industry in 2015.
Work structure

C: Field test and performance evaluation (Polimi)

- WP 1: Standardized Monitoring & Measurement Procedure
- WP 2: Test procedures on system level
- WP 3: Laboratory Tests
  (Warwick/Kiwa)
Dynamic Heat Load Test Rig

- Runs for 24 hours.

<table>
<thead>
<tr>
<th>Test number</th>
<th>Outside T (°C)</th>
<th>Humidity (%)</th>
<th>Regime</th>
<th>Flow (m³/h)</th>
<th>Flow T (°C)</th>
<th>Gas in (kWh)</th>
<th>Electric in (kWh)</th>
<th>Heat output app (kWh)</th>
<th>24h Efficiency of appliance</th>
<th>Heat output rads (kWh)</th>
<th>24h Efficiency of system</th>
<th>Mean Int T (°C)</th>
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<tbody>
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<td>7</td>
<td>57</td>
<td>Bi</td>
<td>1.5</td>
<td>60</td>
<td>156</td>
<td>16</td>
<td>185</td>
<td>108%</td>
<td>185</td>
<td>108%</td>
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<td>64</td>
<td>Bi</td>
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<td>60</td>
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<td>211</td>
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<tr>
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<td>Cont</td>
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<td>45</td>
<td>269</td>
<td>26</td>
<td>342</td>
<td>116%</td>
<td>338</td>
<td>114%</td>
<td>20.8</td>
</tr>
</tbody>
</table>

*¹ Equivalent to the Instantaneous coefficient of the performance (COP) averaged over 24 hours.

*² Equivalent to SPF+4, assuming there are no buffer tanks or domestic hot water (DHW) use.

*³ In addition to the original test regime, an extra test was undertaken with a different flow rate.

*⁴ Test 134 was an extra test with the GAHP, this was undertaken bimodally to check the safety and running of the appliance, so therefore if the tests at 0°C under-heated the property, then the tests were repeated unimodally as per the test programme.
Comparison of manufacturer declared efficiency and experimental efficiencies observed at different flow temperatures

Efficiency calculated based on gas input (gross basis), neglecting electricity input

Where multiple results exist at different flow rates these have been averaged

![Graph showing efficiency vs outside temperature](image)

- **Test results**
  - (Flow T = 45°C)
  - (Flow T = 60°C)

- **Manufacturer declared**
  - (Flow T = 45°C)
  - (Flow T = 55°C)
  - (Flow T = 60°C)
Work structure

D: Market potential study and technology roadmap (CNR-ITAE)

- Simulation study to evaluate different technologies in different climate zones, different building types and building standards
- Combine with market data and actual building stock for technology roadmap (Warwick/Delta-EE input for UK)

E: Policy measures and recommendations, information

- Dissemination
- Workshops for planners, installers and decision makers
- Develop recommendations for policies e.g. building codes and funding schemes
Contents:

• Background to Annex 43 - Fuel (Gas) Driven Sorption Heat Pumps

• State of the art and new developments
Technologies:

- Engines
- Sorption
  - Absorption
  - Adsorption
Absorption
Adsorption

Performance similar in principle
Refrigerants similar:
  • Water
  • Ammonia
  • Alcohols
Existing and near market products:

**Vaillant**

*Technical data of zeoTHERM VAS 106/4*

- Rated heat output range Heating 1.5-10 kW
- Rated heat output range d.h.w. 4.2-12.5 kW
- Adjustable flow temperature 20-75 °C
- Recommended max. flow temperature HC < 40 °C
- El. power consumption max. 100 W
- Appliance width 772 mm
- Appliance height incl. flue outlet 1.700 mm
- Appliance depth 718 mm
- Transport weight (without casing) 160 kg
- Operating weight 175 kg
- Integrated controller
- zeolite module > no moving parts / no maintenance
Existing and near market products:

Vaillant system:
- Water refrigerant, zeolite adsorbent
- Heat pump, solar collector, water storage tank
- Only intended for use with underfloor heating systems with Maximum output temperature of 40°C
- Claimed reduction of annual energy use of 18% compared with a condensing boiler.
- Initial system sale price was around €16,000.
- On market for two years
Existing and near market products:

**Robur**

- Ammonia water absorption
- Air, water and ground source options
- DHW at 65°C (gross COP 1.24)
- 38 kW to radiators (supply temperature 50°C) COP of 1.52 (gross), 1.38 (net).
- Saving of about 40% in gas consumption compared to a condensing boiler.
- Single module 854(w) x 1256(d) x 1281(h).
- 18kW unit, is under development.
- The product is ‘badged’ by BDR Thermea and Bosch
- 40kW unit is c. £12,000.
Existing and near market products:

**Viessmann Gas-Fired Zeolite Compact Heating Appliance**
Features at a glance

- Hybrid Heating Appliance:
  - Heating Power Modulation: 1.6 to 10 kW (1 to 7)
  - Booster capacity for DHW: 15 kW

- SGUE Heating (VDI 4650-2): 135 % (Hi 35/28 °C)
- SGUE Heating (VDI 4650-2): 125 % (Hi 55/45 °C)

- Ambient Heat Source: 2013 GHS
  - From 2014 also Solar
- Working pair completely environment friendly
- Installation, maintenance and service analog to condensing boiler compact units
- Gas-Fired Adsorption Heat Pump in the dimensions of Viessmann compact heating appliances

- Dimensions: BxHxT: 600x595x1875 mm
- Weight: <170 kg (separable in two parts)

Launched 2014
Existing and near market products:

Stiebel Eltron are developing a zeolite – water machine with help from Sortech and similar principal to Vaillant and Viessmann products.
Existing and near market products:

Viessmann Gas-Fired Absorption Heat Pump
Features at a glance

- Wall mounted hybrid appliance:
  - Gas-fired absorption heat pump and a condensing boiler
- Seasonal heating GUE > 1.4 (55/45 °C)
- Seasonal heating GUE > 1.3 (65/50 °C)
- High modulation range (1.6 to 14 kW)
- Dimensions: BxHxT: 600x595x900 mm
- Weight: <90 kg
- Low noise
- Installation & Maintenance comparable to condensing boilers
Existing and near market products:

**Sorption Energy**

Change in product concept over time of project:

Where has the rest of the hardware gone?
Existing and near market products:

**Sorption Energy**

Fits into standard wall-mounted casing

Box-for-box exchange for old boiler

Key competitive advantage
  - other gas-fired heat pumps too large for wall mount

Retrofit market >90% of annual sales

Adsorbent Beds (Generators)
Existing and near market products:
Cooll BV (Netherlands)

Carbon – Ammonia thermal wave adsorption, similar to Sorption Energy. No details available.
Existing and near market products:

**boostHEAT (France)**

“As compared to the latest generation of condensation boilers, the consumption should be reduced by 45 to 60% in low temperature mode (35°C) and by 25 to 40% in medium and high temperature mode (55 to 65°C)”

Thermally driven compressor using CO$_2$ refrigerant.
Thank you!

Questions?